



US006787238B2

(12) **United States Patent**
Zhang et al.

(10) **Patent No.:** **US 6,787,238 B2**
(45) **Date of Patent:** **Sep. 7, 2004**

(54) **TERPOLYMER SYSTEMS FOR
ELECTROMECHANICAL AND DIELECTRIC
APPLICATIONS**

(75) Inventors: **Qiming Zhang**, State College, PA (US);
Zhongyang Cheng, State College, PA
(US); **Haisheng Xu**, Linköping (SE)

(73) Assignee: **The Penn State Research Foundation**,
University Park, PA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 123 days.

(21) Appl. No.: **10/108,231**

(22) Filed: **Mar. 27, 2002**

(65) **Prior Publication Data**

US 2002/0146567 A1 Oct. 10, 2002

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/195,061, filed on
Nov. 18, 1998, now Pat. No. 6,423,412.

(60) Provisional application No. 60/280,303, filed on Mar. 30,
2001.

(51) **Int. Cl.**⁷ **B32B 27/30**; C08F 14/22;
C08F 14/24; C08F 14/26; C08F 16/24

(52) **U.S. Cl.** **428/421**; 428/910; 526/247;
526/249; 526/250; 526/254; 526/255

(58) **Field of Search** 526/250, 247,
526/249, 254, 255; 428/421, 910

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,298,719 A 11/1981 Mizuno et al. 526/255

4,577,005 A * 3/1986 Sako et al. 526/254
4,824,911 A 4/1989 Chu 525/199
5,087,679 A * 2/1992 Inukai et al. 526/249
5,356,500 A 10/1994 Scheinbeim et al. 156/229
6,215,231 B1 4/2001 Newnham et al. 310/371
6,291,106 B1 9/2001 Daido et al. 429/306
6,423,412 B1 * 7/2002 Zhang et al. 428/421

OTHER PUBLICATIONS

Park et al. "Ultrahigh strain and piezoelectric behavior in
relaxor based ferroelectric single crystals." J. Appl. Phys. 82
(4), Aug. 15, 1997.

Ferroelectrics, 1990, vol. 109, pp. 303–308, F. Macchi et al.
"Effect of Electron Irradiation on the Ferroelectric Transi-
tion of P(VDF-TrFE) Copolymers".

Macromolecules 1985, vol. 18, pp. 910–918, Andrew J.
Lovinger, "Polymorphic Transformations in Ferroelectric
Copolymers of Vinylidene Fluoride Induced by Electron
Irradiation".

Nuclear Instruments and Methods in Physics Research, B46
(1990), pp. 334–337, F. Macchi et al., "Micromechanical
Properties of Electron Irradiated PVDF-TrFE Copolymers".
International Search Report for PCT Patent Application No.
PCT/US02/09181, Oct. 10, 2002.

* cited by examiner

Primary Examiner—Ramsey Zacharia

(74) *Attorney, Agent, or Firm*—Ohlandt, Greeley, Ruggiero
& Perle, L.L.P.

(57) **ABSTRACT**

There are disclosed new polymer materials having improved
electric field induced strain levels, dielectric constants, and
elastic energy densities for use in electromechanical and
dielectric applications. Methods of manufacture of new
polymer materials are also disclosed.

5 Claims, 5 Drawing Sheets